CLAIMS

1. A microfluidic system, comprising:

a first microchannel formed in a substrate;

a first communication port coupling the first microchannel to a surface of the substrate; and

a capping module having a matrix having an affinity for selected molecules and a trapping filter for compartmentalizing the matrix on the capping module, wherein the capping module is adapted to be stacked on the substrate and placed in communication with the first microchannel.

2. The system of claim 1, wherein the matrix comprises an array of affinity beads for selectively binding to the selected molecule.

3. The system of claim 2, wherein the affinity beads are coated with binding sites configured to bind to the selected molecules.

4. The system of claim 1, wherein the matrix includes an enzyme for reacting with the selected molecules.

5. The system of claim 1, wherein the matrix includes detection molecules that react with a sample to produce a measurable reaction.

6. The system of claim 1, wherein the capping module includes a chamber for holding the matrix and a first connector port for placing the chamber in fluid communication with the first communication port.

7. The system of claim 6, wherein the capping module includes a second connector port for connecting the chamber in fluid communication with a second communication port that couples a second microchannel to a surface of the substrate, thereby forming a fluid path between the first microchannel and the second microchannel.

8. The system of claim 7, further comprising a capillary electrophoresis column coupled to the second microchannel.

9. The system of claim 1, wherein the trapping filter comprises a semipermeable membrane that is impermeable to the matrix and permeable to selected liquids and molecules.

10. The system of claim 9, further comprising an impermeable layer covering the trapping filter, wherein the impermeable layer does not cover the first and second connector port to allow liquid flow through the first and second connector port.

11. A capping module for a microfluidic system, comprising:

a substrate;

a matrix disposed on the substrate having an affinity for selected molecules, and

a trapping filter for compartmentalizing the matrix on the substrate.

12. The capping module of claim 11, wherein the substrate includes a recess for holding the matrix and the trapping filter covers the recess.

13. The capping module of claim 11, wherein the substrate includes a chamber for holding the matrix and at least one connector port for coupling the chamber to a surface of the substrate, wherein the trapping filter covers the connector port.

14. The capping module of claim 13, wherein the substrate includes a first and second connector port.

15. The capping module of claim 13, wherein the capping further includes:

a first connector port for placing the chamber in communication with a first microchannel,

a second connector port for placing the chamber in communication with a second microchannel,

a third connector port for placing the chamber in communication with a third microchannel, and

a fourth connector port for placing the chamber in communication with a fourth microchannel.

16. The capping module of claim 15, wherein:

the first microchannel, the chamber and the second microchannel form a first fluid path, and

the third microchannel, the chamber and the fourth microchannel form a second fluid path.

17. A molecular fractionation device for a microfluidic system, comprising:

a capping module comprising a substrate defining a region for holding a matrix,

a trapping filter for compartmentalizing a matrix on the substrate;

a connector port for placing the region for holding a matrix in fluid communication with an exterior of the substrate, wherein the trapping filter covers the connector port.

18. The molecular fractionation device of claim 17, further comprising a matrix insertion port in communication with the region for holding a matrix for inserting a matrix into the substrate.

19. A method for segregating molecules based on a selected property comprising the steps of:

providing a first molecular fractionation device including a matrix for binding molecules having the selected property,

flowing a sample containing molecules having the selected property through the matrix, such that molecules having the selected property are retained by the matrix, and

passing molecules not having the selected property through a first outlet of the molecular fractionation device.

20. The method of claim 19, further comprising the step of flowing a solution through the matrix, wherein the solution breaks a bond between the matrix and the retained molecules and passes the molecules having the selected property through a second outlet of the molecular fractionation device.

21. The method of claim 19, further comprising the step of:

separating the molecules having the selected property into a plurality of sub-fractions.

22. The method of claim 21, further comprising the step of:

releasing said plurality of sub-fractions into a microchannel via a second outlet of the device.

23. The method of claim 22, further comprising the step of ejecting one of said sub-fractions from the microchannel.

24. The method of claim 21, wherein the step of separating the molecules comprises the steps of:

flowing an elution buffer through the matrix; and

varying the composition of the elution buffer to separately release the sub-fractions from the matrix as bands of different affinity.

25. The method of claim 23, further comprising the step of electrophoretically separating one of said bands of different affinity into a plurality of sub-bands based on one of: size, charge and charge/mass ratio using an electrophoretic column.

26. The method of claim 25, further comprising the step of ejecting one of said sub-bands from the electrophoretic column.

27. The method of claim 25, further comprising the step of separating a second of said bands into a plurality of different sub-bands after the second band is released from the matrix.

28. The method of claim 19, further comprising the steps of:

passing the retained molecules to a second molecular fractionation device including a second matrix for reacting with the molecules having the selected property.

29. The method of claim 28, wherein the molecules having the selected property comprises a protein, and the second matrix includes trypsin to digest the protein to form a peptide digest.

30. The method of claim 29, further comprising the step of:

passing the peptide digest to a third molecular fractionation device including a third matrix for retaining the peptide digest; and

retaining the peptide digest using the third matrix.

31. The method of claim 30, further comprising the steps of:
passing the peptide digest to a release channel; and
ejecting the peptide digest from the release channel.

32. A method of processing a sample, comprising the steps of:
providing a molecular fractionation device including a matrix having enzymes that react with selected fractions of the sample;
passing a buffer containing the sample through the molecular fractionation device, whereby the enzymes react with and process the selected fractions of the sample to form a reacted sample.

33. The method of claim 32, further comprising the step of:
passing the reacted sample through an outlet of the molecular fractionation device.

34. The method of claim 32, wherein the enzyme comprises trypsin, the sample comprises protein and the reacted sample contains trypsin digested proteins.

35. A method of analyzing a sample, comprising the steps of:
passing the sample through a molecular fractionation device including a matrix including detection molecules that react with the sample to produce a measurable reaction; and
detecting the measurable reaction.

36. The method of claim 35, further comprising the step of:
determining a quantity of the sample based on the step of detecting.

37. The method of claim 35, wherein the detection molecules react with a sample to produce light, or bind to the sample to produce shifts in optical fluorescence or optical absorbency of the detection molecules.

38. The method of claim 35, wherein the detection molecules comprise a luciferin-luciferase system, which emits photons when an ATP molecule is converted.

39. The method of claim 38, further comprising the step of determining a quantity of ATP present in the sample by measuring the photons emitted from the luciferin-luciferase system.

40. A method of fabricating a molecular fractionation device, comprising:
providing a capping module; and
bonding a trapping filter to the capping module to form a chamber for holding a matrix.

41. The method of claim 40, further comprising the step of:
inserting a matrix into the chamber.

42. The method of claim 41, further comprising the step of:
chemically modifying the matrix after the step of inserting the matrix into the chamber.

43. The method of claim 40, wherein the capping module includes a connector port for providing fluid communication between the chamber and an exterior of the capping module.

44. The method of claim 43, further comprising the step of:
assembling the capping module on a microfluidic chip including a microchannel formed in a substrate and a communication port coupling the microchannel to a surface of the substrate, such that the connector port of the capping module is in communication with the communication port of the microfluidic chip.

45. A microfluidic system, comprising:
a first channel for conveying a sample; and
a plurality of molecular fractionation devices coupled to the channel and arranged in series, such that a first outlet of a first molecular fractionation device is in communication with a first inlet of a second molecular fractionation device, wherein each molecular fractionation device includes a matrix having an affinity for a selected set of molecules.

46. The system of claim 45, further comprising a release channel connected to a second outlet of one of said molecular fractionation devices.

47. The system of claim 45, wherein each molecular fractionation device further includes a second outlet, wherein the system further comprises a plurality of release channels, each release channel being connected to a second outlet of one of the molecular fractionation devices.

48. The system of claim 47, wherein each molecular fractionation device further includes a second inlet for providing a buffer solution to the matrix.

49. The system of claim 48, further comprising a filtration system coupled to one of said release channels.

50. The system of claim 49, wherein the filtration system comprising a capping module having a membrane for performing a filtering a sample, wherein the capping module is adapted to be stacked on the substrate and placed in communication with the release channel.

51. The system of claim 49, further comprising a capillary electrophoresis column coupled to the filtration system.

52. The system of claim 45, further comprising an ejection component for ejecting a sample fraction from the system.

53. A method for protein expression profiling, comprising:

fractionating a protein into a plurality of fractions using a plurality of molecular fractionation devices, wherein each molecular fractionation device includes a matrix having an affinity for one of said fractions; and

eluting each of said plurality of fractions from the molecular fractionation devices as bands of different affinities.

54. The method of claim 53, further comprising the step of dialyzing the eluted bands using a semipermeable membrane.

55. The method of claim 54, further comprising the step of injecting one of said eluted bands into a capillary electrophoresis column.

56. The method of claim 55, further comprising the step of electrophoretically separating said band into a plurality of sub-bands.

57. The method of claim 56, further comprising the step of ejecting one of said sub-bands from the electrophoresis column to a plate.

58. The method of claim 57, wherein the sub-band is ejected to one of a multiwell plate and a MALDI spotting plate.

59. A molecular fractionation device, comprising

capping module having a chamber for holding a matrix having an affinity for selected molecules,

a trapping filter for compartmentalizing the matrix in the chamber,

a first connector port for placing the chamber in communication with a first microchannel,

a second connector port for placing the chamber in communication with a second microchannel,

a third connector port for placing the chamber in communication with a third microchannel, and

a fourth connector port for placing the chamber in communication with a fourth microchannel.